PNNL-12024

Environmental Monitoring Alternatives for the Liquid Effluent Retention Facility

M. D. Sweeney

November 1999

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC06-76RLO 1830

Printed in the United States of America

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831;
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Available to the public from the National Technical Information Service,
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Summary

This report outlines the current and future status groundwater monitoring at the Liquid Effluent Retention Facility (LERF) located on the Hanford Site in southeastern Washington State. This facility is regulated under the Resource Conservation and Recovery Act of 1976. The regulations of RCRA require a groundwater-monitoring network that can determine the impact of LERF on groundwater quality. At present, its monitoring configuration complies with the required technical standards. The report will examine alternatives for future compliance to these RCRA regulations and make recommendations regarding possible choices.

Previous studies and current analyses of water level readings indicate a declining water table in the vicinity of the facility. Such a decline indicates the need to investigate reliable, technically sound monitoring alternatives for the future LERF network. The first two chapters discuss the history of LERF and background material on the factors affecting the groundwater chemistry in the area beneath this facility. Previous research also provides a basis for predicting the changes in groundwater elevation, leading to the eventual disappearance of the unconfined aquifer under most of this facility.

Several alternatives are addressed as future possibilities to maintain representative sampling of the unconfined aquifer. Various techniques are described as possible monitoring candidates. They include tracer gas use, electrical resistivity tomography, borehole logging, seismic tomography, and leak detection by excitation of mass. Each of these processes was evaluated and recommendations were made to select three technologies for further consideration. The report contains conclusions on the solution to groundwater monitoring alternatives for the LERF facility.

Acronyms and Abbreviations

B Pond	216-B-3 Pond
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
DST	double-shell tanks
Ecology	Washington State Department of Ecology
ERT	electrical resistivity tomography
ETF	Effluent Treatment Facility
HDPE	high-density polyethylene
HEIS	Hanford Environmental Information System
Hlg	gravel sequence
Hs	sandy sequence
Hug	upper gravel sequence
Hun	undifferentiated gravel-dominated sequence
LERF	Liquid Effluent Retention Facility
LLWMA	Low-Level Burial Ground Waste Management Area
Ma	million years
RCRA	Resource Conservation and Recovery Act
TSD	Treatment, Storage, and Disposal (Facility)
USC	United States Code
WAC	Washington Administrative Code
WHC	Westinghouse Hanford Company
WMA	Waste Management Area

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1.0 Introduction

The 200 Area Liquid Effluent Retention Facility (LERF) is regulated under the Resource Conservation and Recovery Act of 1976 (RCRA). The LERF is included in the *Dangerous Waste Portion of the Resource Conservation and Recovery Act Permit for the Treatment, Storage, and Disposal of Dangerous Waste, Permit WA890008967* (Ecology 1994) (referred to here as the Permit) and is subject to final status requirements for groundwater monitoring (WAC 173-303-645). The RCRA final status regulations require a groundwater-monitoring network capable of determining the facility impact on groundwater quality. The present configuration (Figure 1.1) meets the technical standards for determining compliance, but the future system viability is in doubt.

Historically, the surface disposal of liquid effluents from spent fuel processing has significantly controlled groundwater flow in the 200 Area Plateau. Regional groundwater conditions near the LERF have changed as a result of the recent decrease in artificial recharge Site-wide. Previous studies (such as, Wurstner and Freshley 1994) have attempted to predict this rate of water table decline and its effect on specific monitoring wells, including those at the LERF. Analysis of field water level readings recorded in the Hanford Environmental Information System (HEIS) indicates that several monitoring wells have exceeded their projected lifespan. Adjustments to projected water table elevations are primarily the result of the interim stabilization of the 216-B-3 Pond (B Pond, see Figure 1.1), elimination of non-permitted source discharges, and groundwater treatment projects.

Sitewide water table maps reproduced annually (for example, Hartman 1999), however, confirm that several monitoring wells will not reach the saturated zone in approximately 2 years at the current rate of decline. Two LERF wells (299-E26-9 and 299-E35-2) are particularly at risk due to their proximity to a stratigraphic boundary that defines the base of the unconfined aquifer near the facility.

1.1 Scope and Purpose

The declining water table is the driving force in identifying reliable and technically sound monitoring alternatives to the current compliance network at the LERF. An evaluation of competing techniques, technologies, and monitoring approaches is provided in the following sections. The principal goals of this evaluation are to investigate the feasibility of alternatives to monitoring groundwater and, in a preliminary manner, identify alternative systems that could technically achieve compliance. Ideally, the alternative systems will be confined to readily available products and services, as well as minimize operational and structural impacts to the facility itself.

1.2 History of Groundwater Monitoring at the LERF

A groundwater-monitoring network was installed at the LERF in 1990 before final construction of the facility. Interim-status evaluation of indicator parameters began before waste was transferred to the basins. Samples were collected quarterly from the four wells surrounding the facility (one of them upgradient and the other three downgradient from the LERF) during the first year of monitoring activity,

Figure 1.1. Facility and Well Location Map

then on a semiannual schedule after the critical means for the indicator parameters were established. The LERF is currently monitored under final status regulations and is sampled semiannually. Groundwater sampling and compliance assessment will be performed according to guidance provided in the final-status groundwater-monitoring plan (Sweeney et al. 1997) after it is approved by Ecology.

1.3 Facility Description

This subsection provides an overview of the physical structures and operational history of the LERF. More detail is provided in the *Conceptual Design Report 242-A Evaporation and PUREX Interim Retention Basin* (Rieck 1990).

1.3.1 Physical Structure

The LERF is located in the central portion of the Hanford Site on the eastern boundary of the 200 East Area (Figure 1.1 and Figure 1.2). Construction of the LERF was completed in 1991. This facility, originally classified as a surface impoundment for mixed waste storage, has been permitted as a RCRA Treatment, Storage, and Disposal (TSD) Facility. The LERF received a surface impoundment-treatment exemption from land disposal restrictions (40 CFR 268.4 [WAC 173-303-140]) in 1995 and is now regulated as a treatment facility.

The facility originally was designed to include four basins arranged side-by-side on a 16-ha (39.5-acre) site. Although four excavations were made; only three of them are lined and currently scheduled for use. An interim detection-level network for groundwater monitoring was installed around the LERF in 1990 according to the interim groundwater monitoring plan for the 200 East Area Liquid Effluent Retention Facility (Schmid 1990).

1.3.2 Operational History

The LERF was constructed to provide interim storage of 242-A Evaporator process-condensate of effluent containing listed and dangerous waste constituents (Rieck 1990). From 1977 until 1989, process condensate from the 242-A Evaporator was disposed to the 216-A-37-1 Crib via the 207-A Retention Basins (Smith and Kasper 1983). The 242-A Evaporator was shut down in 1989 and was placed on temporary standby-status, pending construction of a waste-disposal alternative to supplant use of the soil-column crib (Schmid 1991).

Construction of the LERF began in February 1990 with a geotechnical investigation of the site. The facility was completed in November 1993 and was prepared to receive waste from the 242-A Evaporator. The evaporator upgrades necessary for the restart were not completed until 1993; the first waste-reduction campaign did not begin until April 1994.

The effluent from 242-A Evaporator is the result of evaporative condensation of liquids held in the double-shell tanks (DST). Contaminants in the process condensate are expected to consist chiefly of volatile organics that boil off with the water and radionuclides that are entrained in the vapors. The

Figure 1.2. Facility Location and Cross Section Lines

condensate also may contain acetone, methyl ethyl ketone, methyl isobutyl ketone, and tritium. Other aqueous wastes that will be treated and stored at the LERF and the Effluent Treatment Facility (ETF) include, but are not limited to, the following wastes:

- contaminated groundwater from pump-and-treat remediation activities, such as groundwater from the 200-UP-1 Operable Unit

- water from deactivation activities, such as water from the spent fuel-storage basins at deactivated reactors (for example, N Reactor)

- laboratory aqueous waste from unused samples and sample analyses

- leachate from landfills, such as the Environmental Restoration Disposal Facility.

The LERF is linked to Tri-Party Agreement milestones that involve treatment or elimination of selected effluent streams, some of which were previously discharged to cribs, ponds, or ditches. LERF basins have been identified to provide storage capacity for other Hanford Site projects involving contaminated waste streams.

2.0 Geology and Hydrology

This section describes the stratigraphy, physical hydrology, and groundwater chemistry beneath the LERF area. Figure 2.1 and Figure 2.2 provide west to east and north to south cross sections of the LERF area.

2.1 Geology

This subsection summarizes the geology in the vicinity of the LERF. More detailed discussions are found in Delaney et al. (1991), Lindsey et al. (1992), and Sweeney et al. (1994).

The stratigraphy beneath the LERF area, consisting of 61 m of supra-basalt sediments, has been interpreted principally from the four boreholes drilled to construct the groundwater-monitoring network for the facility (Sweeney et al. 1994). Other correlations were made with sediment data from the 200 East Low-Level Burial Ground Waste Management Area 2 (LLWMA 2) and the 216-B-3 Pond (B Pond).

Three principal stratigraphic units are located near the LERF: the Hanford formation, the Ringold Formation, and the Columbia River basalt. The Hanford formation consists of mostly uncemented gravel, sand, and silt deposited by glacial-outburst cataclysmic floods that occurred periodically throughout the Pleistocene Epoch (Fecht et al. 1987, Baker et al. 1991). The Hanford formation has been divided into three lithofacies that grade and transition from one to the other. Lindsey et al. (1992) refers to two of the three facies as 1) gravel-, sand-, and silt-dominated facies and 2) gravel, plane-laminated sand. Baker et al. (1991) refers to the third facies as graded rhythmite. The gravel facies is the predominant lithofacies in proximity to high-energy cataclysmic flood channels such as at the LERF. The sand- and silt-dominated facies are more common southward, away from the axes of the main flood channels. The braided rythmites, found distributed throughout the Site, are a sequence of slack water deposits from low energy environments. More detailed discussions of the Hanford formation are presented in DOE (1988), Baker et al. (1991), Lindsey et al. (1992; 1994), and Connelly et al. (1992).

The Hanford formation under the LERF consists predominantly of a loose, sandy, pebble-cobble gravel, and gravelly sand with occasional layers of sand or muddy sand. Sometimes a sequence of the sand-dominated facies occurs between sequences of gravel-dominated facies (Connelly et al. 1992, Lindberg et al. 1993), especially to the south and west of the LERF site. When this occurs, the Hanford formation is subdivided into an upper gravel sequence (Hug), a sandy sequence (Hs), and lower gravel sequence (Hlg) (Figure 2.1 and Figure 2.2). The sandy sequence is absent beneath the LERF, but is found within a few of the wells surrounding the facility. Where the sandy sequence is missing, a single sequence of gravel-dominated facies exists, designated as undifferentiated (Hun) on the cross sections (Figure 2.1 and Figure 2.2).

The Ringold Formation represents ancient fluvial and lacustrine (lake) deposits associated with the ancestral Columbia River that accumulated sediments in the Pasco Basin between ~3.0 and 8.5 Ma. Characteristics of the Ringold Formation include a higher degree of consolidation and weathering, compared to the Hanford formation. Isolated, erosional remnants of the Ringold Formation exist locally between the Hanford formation and basalt bedrock beneath the LERF. Thin (a few meters) remnants of Ringold Formation occur to the south (Well 299-E25-9 in Figure 2.2). The preserved Ringold sediments are from the older unit (Unit A), identified in Lindsey et al. (1992, 1994), Lindberg et al. (1993), and Connelly et al. (1992).

Basalt was encountered in all four of the boreholes drilled around the LERF area where the top of the basalt generally forms the base of the unconfined aquifer. The four wells in the LERF-monitoring network reached their total depths at the top of the Elephant Mountain Member and are screened across the entire saturated zone in the Hanford formation. These monitoring wells will eventually lose their ability to produce representative samples as the water table moves south along the top of basalt surface. The top of the basalt of the Elephant Mountain Member dips gently to the south with a gradient of 2.0E-02 across most of the 200 East Area (Figure 2.3).

2.2 Groundwater Hydrology

The uppermost aquifer in the LERF area generally resides in the gravels of the Hanford formation. Figure 2.4 shows the water table in the LERF area in June 1999. A regional decline of groundwater elevation has occurred since the installation of the monitoring network. Although regional decreases tend to be gradual, evidence of an annual groundwater elevation decline of approximately 1 m (3.3 ft) was recorded in the vicinity of B Pond in 1997 (Figure 2.5). The resulting changes in groundwater elevation are currently reflected in the saturated thickness penetrated by the LERF network wells (Table 2.1). The results of these changes in groundwater elevation will eventually lead to the disappearance of the unconfined aquifer under most of the LERF (Figure 2.6).

B Pond was the primary source of artificial recharge for 200 East Area, and received an estimated 9.8E11 L of wastewater between 1945 and 1997. The tremendous amount of wastewater discharged to B Pond had a cumulative effect on groundwater elevation and flow direction across the entire 200 East Area. Prior to the initiation of Hanford production, groundwater south of Gable Mountain flowed from west to east. Discharges to B Pond created a subsurface mound that eventually resulted in a man-made lake at the surface as surface waters descended approximately 60 m to the underlying basalt. As a result, groundwater in much of the 200 East Area was forced westward. Since 1988, however, the rate of discharge to B Pond has decreased and the mound is dissipating. Consequently, the flow directions will gradually reverse to an eastward flow toward the Columbia River.

Table 2.1. Aquifer Saturated Thickness Near the LERF

Well	Saturated Thickness (m)
299-E35-2	1.0
299-E26-9	0.6
299-E26-10	4.0
299-E26-11	2.5

foldout

Figure 2.1. West to East Cross Section Through the LERF Area (A-A')

foldout

Figure 2.2. North to South Cross Section Through the LERF Area (B-B')

Figure 2.3. Top of Basalt Structure Contour Map (after Fecht, Reidel, and Tallman 1987)

Figure 2.4. Water Table Elevation (June 1999)

foldout

Figure 2.5. Head Elevation Differential Map

Figure 2.6. Hydrograph of LERF Wells

As groundwater reverts back to pre-production elevations and direction, facilities under RCRA compliance will re-evaluate their line of compliance and reconfigure their networks to accommodate the changes in flow direction and aquifer thickness. In the past, a flow reversal has not been an immediate concern for the LERF monitoring network; it is positioned close enough to the residual B Pond mound to have an obvious groundwater gradient. However, at some future date, the eventual return to a pre-production flow direction would create a significant problem. The drying of the aquifer, and the subsequent lack of water inside the wells, are the most immediate concerns for maintaining a viable groundwater-monitoring network.

3.0 Monitoring Alternatives

The following sections describe alternative monitoring strategies to the current groundwater-monitoring network surrounding the LERF. Consideration is given to all available approaches, including utilization of the LERF basin construction, establishing a monitoring network in the confined aquifer, redefining the point of compliance for the current network, and installation of a vadose monitoring network.

3.1 Basin Construction

The LERF was constructed to meet technical standards for double-lined liquid retention basins. The dimensions of the basins at the anchor wall are 103 m (338 ft) by 85 m (115 ft) at the top with a design capacity of 2.5E07 L. The basins are constructed with primary and secondary liners, consisting of 1.5-mm (0.06-in.) membranes over low-permeability soil composites (DOE 1991).

The leachate detection, collection, and removal system is designed, constructed, and operated to detect, collect, and remove liquids that could permeate the primary liner (Figure 3.1). System components include:

- layer of drainage gravel sloped to a lined sump, high-density polyethylene (HDPE) drainage net on the basin side walls
- perforated leachate riser extending down between the two liners
- dedicated submersible leachate pump installed in the riser piping associated instrumentation.

One scenario for monitoring the LERF includes utilizing the current double-lined system. If a leak should develop in the primary liner, fluids would collect in the drainage layer, flow downslope to the sump, and be detected by the pump embedded in the gravel. The pump operates when the liquid level in the sump reaches 25 cm (9.8 in.) and will continue to operate until the liquid level drops to 5 cm (2.0 in.). The total estimated capacity of the drainage layer to store leachate is approximately 1.8E05 L (DOE 1991).

Regulatory constraints on foregoing compliance monitoring at the LERF are the primary limitations to this particular approach. Washington Ecology would have to grant an exemption for the facility, based solely on the existing technical standards for double-lined liquid retention basins. Without a supporting monitoring approach to ensure compliance, the exemption would not meet the minimum federal standards outlined in 40 CFR 268 and 265.

Notwithstanding regulatory difficulties, the principal technical obstacle to this strategy concerns the basin sumps. In one particular example, a primary liner failure would activate the pumping system that would begin clearing the drainage layer and sump. Without any additional retrieval efforts, the 5-cm

Figure 3.1. Primary and Secondary Liner System

(2-in.) residue from an emergency basin transfer would remain undetected and in constant contact with the secondary liner. Also, because the sump can accumulate fluids up to 5 cm (2.0 in.) in depth without activating the pump, a small, long-term leak that penetrates both liners could go undetected without regularly scheduled visual inspections. Utilization of the double-lined basins for vadose monitoring, under this scenario, could prove to be an expensive alternative to maintain.

3.2 Confined Aquifer Monitoring

The RCRA regulations stipulate that an effective groundwater-monitoring network must assess the quality of groundwater passing the compliance points specified in the permit (generally at downgradient wells). These regulations also specify the quality of background water must not be affected by any leakage from the facility (generally at upgradient wells). The well location strategy implemented in the interim status regulations generally took the form of one upgradient well and a minimum of three downgradient wells surrounding the boundary of the facility.

The LERF monitoring network was designed with this configuration and still operates under it. However, groundwater level decline in the unconfined aquifer will render two of the downgradient wells incapable of generating representative samples. This situation leaves the LERF with two functioning wells, but with inadequate coverage for a point of compliance at the downgradient boundary of the facility.

The RCRA regulations also require the facility to monitor the uppermost aquifer beneath the regulated unit. When groundwater elevations have declined to a level where the facility no longer resides above the unconfined aquifer, the upper basalt confined aquifer becomes the uppermost, saturated unit beneath the LERF. This confined aquifer system consists of the flow bottom of the Elephant Mountain Basalt, the Rattlesnake Ridge interbed, and the flow top of the Pomona Basalt (Graham et al. 1984). Groundwater flow in the upper basalt confined aquifer beneath the LERF is approximately east to west (Spane and Webber 1995).

Regulatory standards for groundwater monitoring are quite explicit regarding the necessity of background monitoring. The capability of the groundwater-monitoring system to assess groundwater quality is dependent on adequate characterization of background water flowing beneath the LERF. Groundwater flowing through the confined system is not representative of the unconfined system where potential contaminants would be deposited (WHC 1990). This situation creates uncertainty in evaluating groundwater quality and would, therefore, not achieve the compliance dictated by the regulations.

3.3 Reconfiguration of Existing System

Even at the current rate of decline throughout the 200 East Area, Wells 299-E26-10 and 299-E26-11 will continue to provide representative samples of unconfined groundwater conditions for several years. To maintain RCRA-compliant configuration, new wells would have to be placed along the southern boundary of the facility. The projected flow direction would be south along the basalt aquitard. However, long-term maintenance would be assured by strategically placing new installations further from the facility boundary.

Similar arguments to those presented in Section 3.2 can be made to describe the limitations of this alternative monitoring strategy. A key regulatory issue for this alternative involves redefining background water quality from a facility scale to a regional scale. Also, several facilities in the vicinity of LERF have received wastes with a similar profile to that stored in the LERF. It is not clear whether the reconfigured system could discriminate between one potential source and another.

3.4 Vadose Monitoring

Vadose monitoring techniques rely on the physical parameters of the sedimentary environment and on the radiological/chemical properties of the contaminants. The most common application of vadose monitoring on the Hanford Site has been based on radiological logging of dry wells in the single-shell tank farms. These investigations have been conducted to evaluate a narrowly focused area of interest, generally in evaluating vertical or lateral contaminant transport. A comprehensive evaluation of vadose monitoring technologies by Lewis and Teel (1994) forms the basis for the following discussion of alternatives for monitoring the LERF. The technologies described rely on soil gas sampling techniques and commonly used geophysical technologies.

3.4.1 Tracer Gas Techniques

Lewis and Teel (1994) identified sampling of soil vapor as an alternative sampling method to cross well geophysics. In this process, gaseous waste components (that is, ammonia and tritium) will diffuse from a leak into the soil vapor and act as tracers to provide an indication of the failure of the secondary containment at the LERF.

In addition to monitoring for the gaseous waste components, injected tracers could also be utilized to identify and quantify the mass of a leak. Since the time of the Lewis and Teel report, tracer gas techniques have significantly advanced, in particular the partitioning of interwell tracer testing. The partitioning tracer technology utilizes the injection of a conservative tracer (for example, sulfur hexafluoride) and one or more partitioning tracers. For use in identifying leaks at LERF, tracers would be injected and swept through the subsurface to extraction points, where they would be measured. Sophisticated techniques for analyzing the arrival time and relative tracer concentrations would provide specific measure of the leak.

Equipment deployment represents the principal difficulty in implementing the tracer gas techniques at the LERF. No current subsurface open intervals exist at the facility for performing tracer gas injection, collection, and analysis. The installation of several wells (or cone penetrometer points) around the perimeter of the basin cells would be necessary for utilizing tracer gas techniques. The wells would need to be coupled with a soil vapor extraction system to pull the tracers through the subsurface. A significant benefit of the soil vapor extraction system is that it tends to dry out a horizon in the subsurface underlying the basins, creating a moisture sink that would help reduce the transport of liquid in the event of a secondary liner failure.

3.4.2 Electrical Resistivity Tomography

The benefits of a properly designed electrical resistivity tomography (ERT) network have been demonstrated in field studies at the Hanford Site (Narbutovskih 1996). The apparent resistivity data analyzed through the use of model curves or forward and inverse modeling computer programs is capable of monitoring the moisture movement through the vadose. An ERT network is currently under consideration for leak detection in the single-shell tank farms.

Electrical signal noise from a variety of sources, including the ERT equipment and pipelines to and from the basins, is the greatest impediment to an ERT installation at the LERF. The basin cell dimensions exceed the maximum configuration necessary to minimize noise in the ERT system. Placement of electrodes in an optimal arrangement would require drilling boreholes, or driving cone penetrometers, in the side walls of the basins.

Because the LERF design did not include vadose monitoring, no provision was made for installing a monitoring network. Any subsequent modification to the basin structure has the potential for undermining the integrity of the secondary liner.

3.4.3 Borehole Logging Techniques

Sensitivity of borehole techniques is dependent on distance from the source to the measured property. The depth of penetration is generally 5 to 30.5 cm (2 to 12 in.) from the borehole casing. The only practical configuration of a logging network would involve drilling horizontally cased boreholes under the LERF basin sumps. As the basins are sloped toward the sumps, this region of the basins would be the area most likely to experience a leak.

3.4.4 Shear-Wave Seismic Tomography

In a manner similar to ERT, shear-wave seismic tomography produces interpretive cross-sectional profiles of the subsurface. The shear-wave energy produced by the downhole source is sensitive to changes in moisture along the ray path. The cross-well configuration would require drilling a series of well borings on opposite sides of the basin to provide adequate profile coverage for imaging the entire subsurface.

A shear-wave seismic network would also require a rigorous sampling schedule. The source would be lowered into a borehole, transmit pulses at various depths, and then move to another borehole. Data gathered from the network would be analyzed by inverse modeling on a computer workstation. Thus, both phases, data acquisition and analysis, are labor intensive.

3.4.5 Excitation of Mass

The excitation of mass, a method of leak detection, relies on establishing a potential field inside the storage basin. Testing consists of measuring the potential field inside or outside the basins for potential leakage. A *potential leak* is a potential field that appears outside the facility and is generated by the charge impressed inside the basins. Tears in the basin liners, or other preferred pathways that bypass the protective barriers, generally cause these potential leaks and their associated fields.

Placement of the charge source and the dipole electrodes constitute the greatest limitation for the LERF. In order to adequately resolve tears in the liners, the charge source and dipole electrodes preferably should be immersed in the basin fluids at all times. This configuration would require placing all source and receiver electrodes under or in the floating cover. An alternative configuration that places the electrodes in the soil would achieve similar results, but with a decrease in resolution. This alternative design, however, would still require placement of the source electrode inside the basin under or in the floating cover. Another consideration that must be addressed is the transfer piping used to move fluids into and out of the LERF. No design model currently exists to address the potential fields that would be created from the transfer pipes emanating from the LERF.

4.0 Recommendations

Maintaining RCRA compliance at the LERF will depend on the ability of the alternative monitoring strategy to detect hazardous waste discharges that would compromise groundwater quality. Whether or not any of the alternatives discussed in Section 3.0 could achieve this objective is dependent on the hydrostratigraphic environment beneath the facility. Finally, the system would have to be installed with a minimum of disruption to the existing facility structures.

The hydrostratigraphy under the LERF has been characterized for monitoring design purposes. The subsurface under the LERF is predominantly Hanford formation sands and gravels underlaid by the Elephant Mountain Member of the Saddle Mountains Basalt. As the site on which the LERF was built had not been used for any known waste management prior to 1990, any moisture in the subsurface above native conditions is probably the result of pre-construction vegetation removal.

The RCRA regulations are quite explicit in mandating groundwater monitoring at the TSD facilities, so the alternative technology must provide protection equivalent to that offered by the current system. Also, retrofitting the existing basins to accept the replacement network must be performed with minimum disruption. Invasive technologies that have the potential to undermine, penetrate, or otherwise compromise the basin liners are considered to be less desirable than those that could perform measurements at a distance from the facility.

With these criteria as guidance, the acceptability of each of alternatives discussed in Section 4.0 was evaluated. A monitoring system that relies on early detection strategies is considered to be the best in achieving compliance. For this reason alone, continued reliance on groundwater monitoring is undesirable for maintaining compliance. By reconfiguring the current groundwater monitoring well network, the LERF becomes part of a regional groundwater-monitoring network that includes past-practice sites whose effect on the subsurface has not been well established. The possibility that contamination from a past-practice site could affect compliance at the LERF dictates avoidance of this method.

Groundwater monitoring of the upper basalt confined aquifer is also undesirable, primarily due to the lack of representative samples that would be drawn from this system. Also, the basalt aquitard would prevent contamination from entering the confined aquifer, so it would go undetected. Additionally, reliance on groundwater monitoring would allow contamination to spread through the vadose zone before detection by a groundwater-monitoring network.

Although not every available geophysical technique was presented in Section 4.0, those capable of gathering the most data without disruption to the present LERF structures were given the strongest consideration. ERT initially held the greatest promise for leak detection at the facility. Unfortunately, the side wall slopes and basin configuration at the surface would make electrode installation difficult, and could create structural problems for the facility. Placing electrodes at a distance sufficient to limit disruption of the basins would also introduce enough noise in the system that analysis of the data would be difficult, if not impossible.

The ability to detect moisture was given highest priority for borehole logging techniques. Neutron logging offers the best opportunity for detecting moisture increases in the subsurface, but the limited penetration of the technique made implementation impractical. Horizontal borings running beneath the basins would have increased the range of the system; however, the number of borings providing optimum coverage would raise serious concerns about disrupting the structural integrity of the basins.

Three technologies were selected for further consideration based on availability and minimal operational and structural impacts to the facility. Consideration should take the form of a feasibility study that will evaluate the cost of implementing the competing technologies, and would define scope/budget for implementation. One of the techniques, soil-gas sampling, would be used in conjunction with either shear-wave seismic tomography or a system based on the principle of excitation of mass.

Periodic soil gas surveys can be conducted with properly designed boreholes, or with cone penetrometers. A shear-wave seismic network is capable of producing data of sufficient quality to track moisture through the vadose. This early indication of liner leaks is thought necessary as a substitute for assuring compliance through groundwater sampling. The highly interpretative techniques used to image the data would be supported by more direct means through a dedicated soil gas sampling system. The soil gas system would be designed to detect elevations in tritium concentrations in the soil, as well as for the presence of ammonia.

Consideration should also be given, however, to a network design that incorporates excitation of mass and soil gas sampling. Although significant design questions have not been resolved with respect to an excitation of mass implementation specific to the LERF, the technology is promising from technical and cost considerations. The system has been successful at other facilities and is capable of detecting small tears (approximately 5 cm or about 2.0 in.) in liners (Laine et al. 1997). The cost for deploying this technology, due to a reduced reliance on borehole drilling, is also attractive. The system could be installed with electrodes that *do not* require drilling. Because it does not depend on a wire-line source to produce a signal, the system could be designed for remote operation. Operational costs for the system could be confined to the analytical time for modeling the data, a cost that would be borne by either of the two competing technologies.

5.0 Conclusions

This report was intended to provide information on available alternatives to groundwater monitoring at the LERF. As the water table will eventually decline to a level where half of the monitoring wells in the network will fail to produce representative groundwater samples, the question of whether to consider a monitoring alternative cannot be avoided. The LERF and the 200 Area ETF were included in the Permit in 1998 and compliance monitoring for the facility was a critical permit condition.

The form for this monitoring alternative has not been decided, and neither the Department of Energy (DOE) nor Ecology has formally addressed the issues raised in this report. The foundation for an integrated approach to vadose monitoring has been initiated and the data quality objectives for applying vadose technology are under review. However, no attempt was made to anticipate the final disposition of these activities. The criteria used to select the appropriate monitoring technique were based solely on the requirements outlined in Section 1.1. These include technical approach, availability of commercial applications, and minimal facility impact.

A detailed feasibility study was also beyond the scope of this project. Because the LERF is a permitted facility, public comment will necessarily follow negotiation between the DOE, regulators, and stakeholders. A decision on the exact type and design of an alternative monitoring network cannot proceed until this process has been finalized.

6.0 References

Public Laws

Resource Conservation and Recovery Act of 1976, as amended, Public Law 94-580, 90 Stat. 2795, 42 USC 6901 et seq.

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